The Role of the Root Cell Wall in Aluminum Toxicity

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Abstract:
Aluminum (Al), the most common metal of the earth's crust, is highly toxic to roots of many plant species when present in solution as monomeric cations (e.g., $Al^{3}+$, $AlOH^{2}+$) at a concentration as low as 10 µM. Despite this long-known effect, there is little consensus on the biochemical basis of Al toxicity, which may be manifest either external to or within the symplasm. There is increasing evidence that the vast majority of Al in *Chara corallina* nodal cells occurs in the cell wall, for example. The Al which accumulates at the apex of plant roots is bound both rapidly and strongly by negatively-charged pectic compounds (predominantly α-1,4 D-polygalacturonic acid). It is proposed that the accumulation of Al in the cell wall exerts a detrimental effect on root growth and function in three ways. First, the decrease in apoplastic sorption of basic cations, which have limited ability to displace bound Al, reduces nutrient acquisition per unit root length. Second, the Al sorbed in the cell wall reduces cell expansion, thus reducing root elongation (a major visible effect of soluble Al). This would also reduce nutrient uptake through decreased root proliferation through the soil. Third, sorption of Al in the cell wall reduces the movement of water and solutes through the apoplasm, directly decreasing nutrient acquisition by the root.